

What is claimed is:

1. A method for etching a ruthenium film, comprising:

5 etching a ruthenium film formed on a substrate with a chemical liquid having a pH of not less than 12 and an oxidation-reduction potential of not less than 300 mVvsSHE.

2. The method according to claim 1, wherein said chemical
10 liquid is maintained at a pH of not less than 12 by using ammonia, an organic alkali or an alkali hydroxide.

3. The method according to claim 1, wherein said chemical
15 liquid is maintained at an oxidation-reduction potential of not less than 300 mVvsSHE by using a halide oxidant.

4. The method according to claim 1, wherein said chemical
20 liquid comprises a strongly alkaline oxidant solution or a mixed solution of an alkali solution and an oxidant solution, and said strongly alkaline oxidant solution or said mixed solution is supplied to a predetermined portion of the ruthenium film formed on the substrate.

5. The method according to claim 4, wherein said strongly
25 alkaline oxidant solution comprises a solution of a halogenated oxygen acid salt selected from hypochlorite, chlorite, and bromate.

6. The method according to claim 4, wherein said alkali solution contains at least one of ammonia, tetramethylammonium hydroxide, and trimethylamine;

wherein said oxidant solution contains at least one of
5 bromine, iodine, chlorine dioxide, and ozone.

7. The method according to claim 1, further comprising;
supplying an alkali solution and an oxidant solution separately to a predetermined portion of the ruthenium film formed
10 on the substrate; and

mixing said both solutions at said predetermined portion to prepare said chemical liquid.

8. The method according to claim 7, wherein said alkali
15 solution contains at least one of ammonia, tetramethylammonium hydroxide, and trimethylamine;

wherein said oxidant solution contains at least one of bromine, iodine, chlorine dioxide, and ozone.

20 9. An apparatus for etching a ruthenium film, comprising:
a substrate holder for holding and rotating a substrate;
a center nozzle disposed above a central portion of the substrate held by said substrate holder for supplying ultrapure water to a surface of the substrate; and

25 an edge nozzle disposed above the peripheral portion of the substrate held by said substrate holder for supplying a chemical liquid having a pH of not less than 12 and an oxidation-reduction potential of not less than 300 mVvsSHE to the surface of the

substrate.

10. The apparatus according to claim 9, further comprising
a back nozzle disposed beneath the central portion of the substrate
5 held by said substrate holder for supplying a chemical liquid having
a pH of not less than 12 and an oxidation-reduction potential of
not less than 300 mVvsSHE to a backside of the substrate, or mixing
an alkali solution and an oxidant solution to make a chemical liquid
having a pH of not less than 12 and an oxidation-reduction potential
10 of not less than 300 mVvsSHE at the backside of the substrate.

11. An apparatus for etching a ruthenium film, comprising:
a substrate holder for holding and rotating a substrate;
a center nozzle disposed above a central portion of a
15 substrate held by said substrate holder for supplying one of an
alkali solution and an oxidant solution to a surface of the
substrate; and

an edge nozzle disposed above the peripheral portion of the
substrate held by said substrate holder for supplying the other
20 one of said alkali solution and said oxidant solution to the surface
of the substrate;

wherein a mixture of said alkali solution and said oxidant
solution has a pH of not less than 12 and an oxidation-reduction
potential of not less than 300 mVvsSHE.

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12. The apparatus according to claim 11, further comprising
a back nozzle disposed beneath the central portion of the substrate
held by said substrate holder for supplying a chemical liquid having

a pH of not less than 12 and an oxidation-reduction potential of not less than 300 mVvsSHE to a backside of the substrate, or mixing an alkali solution and an oxidant solution to make a chemical liquid having a pH of not less than 12 and an oxidation-reduction potential
5 of not less than 300 mVvsSHE at the backside of the substrate.

13. An apparatus for etching a ruthenium film, comprising:
a substrate holder for holding and rotating a substrate;
a rotatable chemical liquid applicator that can be brought
10 into contact with a bevel region of the substrate held by said substrate holder; and
a chemical liquid supply pipe for supplying a chemical liquid having a pH of not less than 12 and an oxidation-reduction potential of not less than 300 mVvsSHE to said chemical liquid applicator.
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14. The apparatus according to claim 13, wherein said substrate holder comprises a vacuum-chuck for sucking and holding the substrate.

20 15. The apparatus according to claim 13, wherein said chemical liquid applicator comprises a sponge roll.

16. An apparatus for etching a ruthenium film, comprising:
a substrate holder for holding a front surface of a substrate
25 in a non-contact manner and rotating the substrate; and
a back nozzle disposed so as to be directed toward the central portion of a backside of the substrate held by said substrate holder;

wherein while flowing an inert gas along the front surface of the substrate, a chemical liquid having a pH of not less than 12 and an oxidation-reduction potential of not less than 300 mVvsSHE is supplied from said back nozzle to the backside of the substrate.

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17. The apparatus according to claim 16, wherein said substrate holder comprises a Bernoulli chuck.